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Research Article

Influence of retreatment in the formation of dentinal microcracks in mandibular molars filled with a calcium silicate based sealer

Luciana da Cruz Ribeiro Jorge[1], Fabiola Ormiga[1], Aline Neves[2], Ricardo Tadeu Lopes[3] and Heloisa Gusman[1]*

[1]Federal University of Rio de Janeiro, School of Dentistry, Department of Dental Clinic, Rio de Janeiro, Brazil

[2]Federal University of Rio de Janeiro, School of Dentistry, Department of Pediatric Dentistry, Rio de Janeiro, Brazil.

[3]Federal University of Rio de Janeiro, Technology Center, Department of Nuclear Instrumentation Laboratory, Rio de Janeiro, Brazil

Abstract

Introduction: In endodontically treated teeth, dentinal defects such as microcracks can progress to a vertical root fracture and lead to tooth loss.

Objective: The present study aimed to evaluate, by micro-computed tomography analysis, the formation of dentinal microcracks during filling removal in endodontic retreatment of root canals filled with gutta-percha and Total Fill BC bioceramic sealer.

Methods: Twenty mesial roots of mandibular molars were instrumented and obturated with gutta-percha and Total Fill BC sealer and then the filling material was removed with rotary Protaper Retreatment files. The specimens were scanned before instrumentation, after filling and after retreatment. The transversal images obtained after filling were compared with the images obtained after removal of the filling material. A descriptive statistical analysis was performed.

Results: Among the 24.444 cross-sections analyzed, 5.67% presented some type of dentinal defect, with 0.51% in the initial images, 2.58% in the post-filling images and 2.58% in the post-retreatment images. All the dentinal defects identified in the images obtained after the retreatment were already present in the corresponding images after the filling. New dentinal microcracks were not observed after removal of the filling material.

Conclusion: Retreatment of mesial roots of mandibular molars filled with a silicate-based root canal filling material do not influence the formation of dentinal microcracks.

More Information

***Address for Correspondence:** Heloisa Gusman, Rua Professor, Rodolpho Paulo Rocco 325/2° andar, Ilha da Cidade Universitária, Rio de Janeiro 21941-913, Brazil, Tel: 55 21 996312426; Email: heloisa.gusman@odonto.ufrj.br; heloisagusman@gmail.com

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Introduction

Vertical root fracture (VRF) is defined as a severe crack longitudinally along the central axis of the root and may extend from the interior of the root canal to the external surface of the root [1]. In endodontically treated teeth, dentinal defects such as microcracks, may progress to a VRF which can lead to tooth loss [2,3].

Some studies have evaluated, by micro-CT, the formation of microcracks after chemical-mechanical preparation with different instruments [4-10]. In most of these studies, the formation of new microcracks was not observed, regardless of the type or kinematics of the instrument used (continuous or reciprocating rotation) [4-6,8,10]. De Deus, et al. [5] using micro-CT and stereomicroscopy demonstrated that the defects identified in the stereomicroscopy analysis were already present before instrumentation or were absent at both times of the micro-CT analysis, indicating that the formation of defects resulted from the sectioning procedure performed prior to the stereomicroscopy. The studies that found microcracks did not report the use of a software to co-register the image stacks [7,9], which confirms whether the same slice was analyzed and if it was in the same position, whilst this could raise doubts about the real presence of new microcracks [6].

Other studies have also evaluated the formation of microcracks after filling procedures [11] and after gutta-percha removal during retreatment [12]. These studies did not observe new microcracks after different filling techniques with AH plus sealer [11] and after retreatment with AH26 sealer [12].

The complete removal of the filling material during retreatment is essential for adequate cleaning and disinfection of the root canal system, thus playing an important role in the success of endodontic therapy [13]. Filling material can be removed using heat and instruments with or without gutta-percha solvents [14]. The use of rotary nickel–titanium (NiTi) instruments is safer and faster than the use of manual instruments, reducing operator and patient fatigue [15].

Bioceramic sealers fill most of the properties desired for an ideal root canal sealer: antibacterial properties, biocompatibility and radiopacity [16]. Due to their chemical composition and interaction with dentin walls, some studies raised concern about the difficulty of their removal during retreatment, owing to the possible formation of dentinal defects [17,18].

The chemical-mechanical preparation and root canal filling using different techniques do not seem to influence the formation of dentinal microcracks. However, few studies have evaluated the influence of retreatment on the formation of these defects, particularly in root canals obturated with bioceramic sealers. Therefore, the purpose of this study was to evaluate the formation of dentinal microcracks during filling removal in endodontic retreatment of root canals filled with gutta-percha and Total Fill BC bioceramic sealer.

Methods

Sample selection and image acquisition

The present study was approved by the ethics and research committee of University Hospital Clementino Fraga Filho under the protocol number 02235718.0.0000.5257. A total sample size of twelve was found using Wilcoxon signed rank test for one sample case with an α error of 0.05 and a power of 80% (G*Power 3.1). Twenty mandibular molars were atraumatically extracted for clinical reasons and stored in 0.1% thymol solution at 4ºC until use. Teeth with caries, calcified canal, internal or external resorption were excluded from the study. The teeth were then analyzed by micro-CT to confirm similarity to the anatomy.

A custom-made mold of self-polymerizing resin was created for each tooth to standardize the mounting of the specimen [19]. The teeth were placed in a micro-CT scanner (SkyScan 1173; Bruker, Kontich, Belgium) on a custom aluminum attachment. This base ensured the standardization of the images obtained initially and after the canal obturation and retreatment, as it allowed precise re-placement of the sample inside the scanner. Scanning was performed through 360º rotation with a rotation step of 0.30 using a 1.0-mm thick aluminum filter, 70-kV energy, 114-mA current, 14.8-mm pixel size, and 21.39-mm resolution.

Root canal treatment

The root surfaces were covered with a light-based silicone molding material to simulate the periodontal ligament and around the specimens were added a self-curing acrylic resin to act as a support. Mesial roots were instrumented with the NiTi K3XF file system (SybronEndo, Orange, Canada) following the sequence: # 25/.08, # 25/.06 and # 25/.04. Files were used passively and apical enlargement was performed using files # 25.06 and # 30.04. The pulp chamber was filled with 5.25% sodium hypochlorite (NaOCl) throughout the instrumentation. The canal was irrigated with 3 ml 5.25% NaOCl after each instrument. After instrumentation, all canals were irrigated with 3 ml 17% EDTA for 3 minutes (1 ml/min) and 3 ml 5.25% NaOCl, and dried with FM-size paper points (SybronEndo). Then, root canals were filled with Total Fill gutta-percha cones (FKG, La Chaux-de-Fonds, Switzerland Brasseler) # 30 or # 35 and Total Fill BC Sealer (FKG, La Chaux-de-Fonds, Switzerland). The filling was performed according to the manufacturer's recommendations, using the Single Cone Technique. Then, the coronal sealing was performed with cotton and zinc oxide-based temporary material, and the teeth were stored for 7 days in an oven at 37ºC and 100% humidity for the total setting of the sealer. The teeth then underwent a new micro-CT image acquisition.

To remove filling material, a #3 Gates Glidden drill (Dentsply-Maillefer) was used in the cervical 3 mm. The nickel–titanium (NiTi) ProTaper Universal Retreatment (PTUR) (Dentsply-Maillefer) sequence was employed according to the manufacturer's instructions: D1, D2, and D3 were used in the cervical, middle, and apical regions, respectively, without solvents. The removal of the filling material was considered complete when no gutta-percha residue or sealer was observed in the instrument and the working length was reached. After this step, a NiTi ProTaper Next X4 file (#40.06) (Dentsply-Maillefer®) was used up to the working length, followed by irrigation with 5 mL 5.25% NaOCl. The teeth then underwent a new micro-CT image acquisition.

Analysis of dentinal defects

The 3D Slicer v.4.6.2 software (available at http://www.slicer.org) was used to co-register the stacks of images by an automatic overlay process based on the external root contour. Then, cross-sectional images of the mesial roots, from furcation to apex (n = 24,444), were analyzed by 3 experienced endodontists who were trained to identify the presence of dentinal microcracks. To verify the formation of new cracks, the images obtained after the filling were analyzed and compared with the images obtained after the removal of the filling material in the Image J software. Defects were

defined either as visible cracks that extends from the dentinal wall inside the root canal but did not reach the external root surface or visible crack extending from the inside dentinal wall of the root canal to the external root surface.

Statistical analysis

A descriptive statistical analysis was performed using SPSS 25.0 software (IBM Corp. Chicago, IL). The results were expressed as the relative percentage of the number of sections with dentinal microcracks. To compare the relative percentages of dentinal microcracks in the initial, post-filling and after removal of material filling images, Chi-square test was used. The level of statistical significance was 5% (SPSS v20.0, Chicago, USA).

Results

A total of 24.444 slices were analyzed. From these slices, 5.67% (n = 1.386) showed some dentinal defects, with 0.51% (n = 125) in the initial images, 2.58% (n = 630) in the post-filling images, and 2.58% (n = 630) in the images obtained after the removal of the filling material. There was no statistical difference ($p > 0.05$) in the relative percentages of dentinal microcracks in the initial, post-filling and retreatment images. When the initial and post-filling images were compared, it was observed that 1.65% (n = 403) of the slices showed new microcracks. All the dentinal defects identified in the analysis of the images obtained after the removal of the filling material were already present in the corresponding images obtained after the filling. Therefore, no new microcracks were observed after the removal of the filling material.

Discussion

This study evaluated the presence of dentinal microcracks after the retreatment of mesial roots of mandibular molars filled with gutta-percha and the bioceramic Total Fill BC sealer. The results showed that new microcracks were not formed after the removal of the filling material, and all the dentinal defects identified in the analysis of the images obtained after the removal of the filling material were already present in the corresponding images obtained after the filling.

The control for this study was the images obtained by micro-CT after root canal filling. These images were compared with the ones obtained after the retreatment of the canals, since the objective was to evaluate the incidence of dentinal microcracks generated during this procedure. The micro-CT analysis performed previously to the chemical-mechanical preparation of the canals had the objective of verifying the similarity of the root canals in terms of the anatomy. The analysis after the chemical-mechanical preparation was not performed since this analysis was not necessary for the evaluation proposed for the study. Moreover, most of the *in vitro* studies that evaluated the incidence of microcracks after the instrumentation failed to notice new microcracks related to this procedure. [4-6,8,10]. Furthermore, a recent *in vivo* study confirmed that root canal instrumentation with either rotary or hand instruments did not result in the formation of dentinal microcracks [20].

Rotary instruments are recommended for removing filling material during root canal retreatment because they are fast, safe and efficient. In the present study, PTUR was selected for its proven effectiveness and safety in the apical extrusion of debris [21,22]. Furthermore, no gutta-percha solvent was used during retreatment, as its use is still controversial in the literature. Although the use of solvent favours the penetration of instruments in the obturation mass, it has been shown by MEV that the dentinal tubules of teeth re-treated with solvents can be obliterated by residues of gutta-percha and sealer, thus making root canal system cleaning difficult [23].

The results reported herein are in accordance with others that did not observe production of microcracks in micro-CT analysis after chemical-mechanical preparation and root canal filling [4-6,8,10]. Our results are also in agreement with Yilmaz et al. [12], who did not observe new microcracks after retreatment of canals filled with gutta-percha and AH26 sealer.

Divergent results were reported by Jani, et al. [24] that found a significant increase in the formation of dentinal microcracks after root canal preparation, followed by obturation and retreatment [24]. They showed by micro-CT analysis that all the three root canal therapy procedures generate dentinal defects, with a maximum number registered during retreatment with PTUR file system. The discrepancy in the results may be explained by the methodological differences, such as sample used, the type and resolution of the microtomograph device and the fact that the teeth were not mounted in a silicone base material to simulate the periodontal ligament. This is an important consideration and a limitation of the *in vitro* studies. The presence of periodontal ligament and the surrounding alveolar bone plays an essential role in distributing forces, therefore, it is important to either use a soft material to involve the teeth, like it was done in our study, or to perform the experiments using human mandibular or maxillary cadavers [25-27]. Furthermore, *in vitro* conditions without standardization of age and pre-extraction conditions may explain the divergent results. It has been reported that VRF is more common in patients older than 40 years of age, since root dentin in older individuals may exhibit a decrease in strength and resistance to fatigue because of the changes in the microstructure and chemical composition [20].

Conclusion

It is possible to conclude that no formation of dentinal defects was associated with retreatment of root canals filled with gutta-percha and Total Fill BC sealer.

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